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" *O fortunatos nimium sua si bona norint*
" *Agricolas.*" . . . VIRG.

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AGRICULTURE.

The following ESSAY, on SOILS, and the means of rendering them *permanently fertile*, was written by a practical farmer, in the state of Virginia, who some years since determined to examine into the nature or composition of the Soils in his vicinity; and who, at the same time, commenced a course of experiments to ascertain the permanent as well as the immediate effects of several manures. He has now given an account of the modes and results of his examinations of many soils—accompanied by detailed statements of the effects of specified manures upon several crops, cultivated upon soils of known properties.

This Essay presents the first systematic attempt that has fallen under our observation, wherein a plain, practical, unpretending farmer, has undertaken to examine into the real composition of the soils which he possesses, and has to cultivate. And we think it would be impossible too highly to commend the disposition which he has shewn to ascertain the real character of his land, and the true value and effect of different manures; for it is only thus, that we can be taught understandingly to apply manures for the immediate increase of our crops, and permanent benefit of our soils.

And we rejoice with him, and for our country, at the circumstances of his investigation having been crowned with a rich reward—the approbation of his neighbours, and of the Delegation of the United Agricultural Societies of the state of Virginia; added to the satisfaction which he should derive from the consciousness of having assiduously and usefully devoted a portion of his time to the advancement of the great interest, *the permanent profitableness* of a pursuit, on which the prosperity of the nation mainly depends.

His ESSAY deserves to be studied by every Farmer, and his example should be followed by every intelligent cultivator of the soil; all of whom may possess the means, for they are but simple and but of little cost: and many there are, in every district of this wide spread country, who could and ought to make similar examinations and experiments for themselves and their neighbours.

It is not enough to excuse these persons from such undertakings, that they have not made chemistry their study: it is their business, and therefore their duty to understand many things critically, which properly form a part of that science. The composition of soils, as regards their particular fitness or adaptation to the growth of one or another plant; with their susceptibility of immediate, and fleeting or lasting improvement, by the application of the different manures, that are accumulated by our own industry and management, or which may be found ready formed by nature in almost every vicinity; are subjects easy to be understood by all, who will take the trouble to inquire strictly into them. The little knowledge of chemistry that is necessary to the comprehending of such matters, as far as they are practically connected with farming operations, will be readily acquired by every one as he advances in his investigations. And that every reader, who will do us the favor to peruse this Essay, may follow the author in his argument without the interruption that might occur for want of chemical works, or a knowledge of the terms used in that science, we shall for ready reference append explanations for the use of such persons, and refer them to substances and their modifications as they are commonly seen and spoken of. We shall do this in the hope that we may induce each reader of the American Farmer, to bring his mind to the perfect understanding of the author's opinions, so as to form a correct estimate of the great importance of pursuing such investigations and experiments in every section of this country. Let no one consider these matters as out of his sphere, or beyond his power to comprehend, for it is only necessary to be willing in order to be able to understand them fully. On this point we would be urgent; and we hope to be successful, when we entreat our readers, one and all, to think and act in reference to the subject of this *essay* as we believe their true, immediate and lasting interests require that they should. We beseech them not only to read but study it; and resolve to follow the bright example which its unassuming author has so clearly and laudably set before us. And may we not hope, that his appeal to the votaries of science, will be felt by the professors of chemistry in our Universities, and his wishes be sooner realized, thro' their willing co-operation than he seems to hope?

Such are our favorable impressions as to the merits of this essay, that we have determined to extend its circulation by issuing, and gratuitously distributing an extra impression of this number of our Journal.

Editor Am. Farmer.

ON THE COMPOSITION OF SOILS, AND THEIR IMPROVEMENT BY CALCAREOUS MANURES.

Received from the Agricultural Society of Prince George, by the Delegation of the United Agricultural Societies of Va. Dec. 6, 1821.—Read and ordered to be printed in the AMERICAN FARMER.

Three years ago, I ventured to lay before this Society, opinions respecting the nature of soils, and the action of calcareous manures, which had then received no support from my own experience, and but little from that of others. I was fully aware of the risk, in presenting a theory so general and comprehensive in its application, and on that account, so easy to overthrow, if untrue: but I was induced to take that course, from my conviction of its correctness, and the hope of gaining the assistance of others, towards furnishing the proofs, which numerous and varied experiments with calcareous manures, could only afford. It was my intention to resume the subject, whenever I should be able to offer practice, as well as theory, and either to sustain the opinions before advanced, or to acknowledge whatever experience might show to be erroneous.

The propositions formerly submitted, were as follows:

That soils are essentially different in their capacity for improvement, from some general cause which is far more operative, than such particular and auxiliary causes, as being stiff or light, moist or dry, level or hilly.

That soils under similar circumstances, are capable of improvement, by animal and vegetable manures, in proportion to the degree of their natural fertility.

That the fertility or barrenness of soils, is caused by the presence or absence of a proper proportion of carbonate of lime, or calcareous earth; and of course that the quantity which soils contain of this ingredient, measures their capacity for improvement.

That the fertilizing effects of calcareous earth, are principally produced by its power of combining manures with soils, between which there would otherwise be no attraction, and of neutralizing acids, which exist in all soils destitute of calcareous matter.

That for the want of these properties, it is impossible to improve poor soils with profit, by means of animal aud vegetable manures, without previously correcting the defect in their constitution.

The different capacities of Soils for improvement.

Of the foregoing propositions, none perhaps will so readily obtain the assent of experienced cultivators, as those which affirm soils of similar texture to possess very unequal capacities for improvement, and that the degree is in proportion to their original productiveness. These facts, however, so important to every rational scheme of improvement, appear to have excited but slight, if indeed any attenion, either in Europe or America. To make and apply as much manure as possible, seems to be considered by all writers, as sufficient to insure fertility to the soil, and profit to the cultivator. They do not tell us, that many exceptions to this rule may be found, and that some soils, without any apparent defect, if not incapable of being enriched by animal and vegetable manures, would at least cause more loss than profit by their improvement.

Some persons admit this difference in soils, but consider a deficiency of clay to be the obstacle to permanent improvement. The general excess of sand in our poor lands, would warrant this belief to a superficial observer. But clays, in proportion to their extent, are as frequently found poor, as sands, and the most steril bodies of land in this county, are also the stiffest. A poor clay soil will certainly retain manure longer, and may be rendered more productive than a poor sandy soil: but when the difference of expense in manure and cultivation, is considered, I doubt whether the improvement of the lighter soil would not be attended with more profit, or rather with less actual loss.

If all soils of similar texture, were equally capable of being enriched, we should not see extensive districts altogether rich, or altogether poor, and which have maintained their respective characters, from the time they were brought under cultivation. It cannot be supposed that every farmer in one district is

an improver, and in the other, every one an exhauster. If soils were equally fit to be improved, we should see their value vary as much, as the industry and intelligence of their owners. Animal and vegetable manures, applied to any amount whatsoever to the clays of Prince George, or the sands of Sussex, would not make them as valuable as the stiff lands of Back river, or the light loam of Nansemond: and even if such means caused the greatest productiveness, not as much would be retained after five years of exhaustion, as the others now shew after a century.

Calcareous earth the cause of fertility.

Soils containing a proper proportion of calcareous earth, are invariably rich in their natural state, and those which are steril, either contain an excessive quantity, or are totally destitute of this necessary ingredient.

This opinion was formed entirely on the visible qualities of soils, and the effects of calcareous manures. But it is obvious that the only certain test of its truth, is an accurate and extensive examination of soils of different characters, by chemical analysis, and thus ascertaining the exact proportion of carbonate, or other compounds of lime, contained in each. This did not appear very difficult to perform, according to Professor Davy's directions, even though the operator might possess but slight knowledge of chemistry in general. Under this impression, I did not fail to attempt obtaining proof in this way, though unacquainted with either the theory or practice of chemistry, and without any opportunity of receiving instruction, from communication with others who were better informed. Thus situated, perhaps it would have been better (and certainly more prudent) to leave such investigations to those who are fully competent. I should have chosen that course, had there been any hope of similar operations from chemists; but their almost total neglect of the chemistry of agriculture, leaves no ground to expect a change, until farmers themselves point out the abundant harvest of discovery, which will hereafter reward some successful investigator.

When the proportion of carbonate of lime in a soil is considerable, and perfect accuracy is not essential, its amount may be easily ascertained, by the first process described in Davy's "Agricultural Chemistry." But it is not sufficiently exact to determine the character of a soil, when an error of one grain in 100, would class it incorrectly. The inaccuracies attending this mode, arise from the muriatic acid, which is used to dissolve the lime, taking up also a small portion of clay and vegetable matter; all these will be precipitated together, by the carbonate of potash, and cannot be separated without a subsequent process, which (from the small quantities usually obtained) would be both difficult and uncertain. If compounds of lime & vegetable acids are present, (which for reasons hereafter to be stated, I believe to be common ingredients of soils,) they would appear in the result as carbonate of lime, although the soil might not have contained a particle of the latter substance.

The analysis by means of the Pneumatic Apparatus, (of which a plate and description are given in Davy's "Agricultural Chemistry,") is liable to none of these errors; and when the few which are peculiar to this mode are guarded against, its accuracy is almost perfect in ascertaining the proportion of the single substance, to which its use is limited. It should be remembered, that it indicates the presence of lime in no other form, but when combined with carbonic acid. By means of this apparatus, my examinations have been made, with much care, and I think with as much accuracy, as can in any case be expected.

It is very probable, that from ignorance of some particular properties of the substances used, I may have been betrayed into gross errors, without suspecting it. Should this be the case, I would gladly be corrected; and for that purpose, I shall explain the process by which I examined soils, more fully, than its importance merits. Most farmers are determined *not* to understand any thing, however simple it may be, which relates to chemistry: I hope this resolution will for once be suspended, on my assurance that I shall speak of no process, which may not be well understood, or even repeated, by persons who possess no knowledge of that science.

The Pneumatic Apparatus ascertains the proportion of carbonate of lime in a soil, by measuring the carbonic acid gas evolved, on the application of a stronger acid. Nothing, therefore, can be mistaken for that earth, unless it is also combined with carbonic acid. Magnesia is the only other substance in soils thus combined, and when present, appears in the result as lime. Its amount however, is so inconsiderable, as scarcely ever to affect the true result. There is another slight source of error; a small quantity of carbonate of lime, varying between half a grain & three grains, will always be lost to the result, either by the condensation or absorption of a part of the gas, or from the acid not reaching every particle of soil. This was ascertained, by frequently submitting to examination, known quantities of pure chalk, either alone, or mixed with other earth. Whether much or little was tried, the loss was always as above stated, except that when chalk was used alone, the loss never amounted to one grain. To diminish as much as possible even this small error in the results, large quantities of soil were used, and to each, a small known quantity of pure chalk was previously added, and as much deducted from the result. This served not only to shew a proportion too small to be otherwise indicated, but also, when no other carbonate of lime was present, it proved in every experiment whether the apparatus was in good order, and the result perfectly correct. Muriatic acid was applied to the soil, to considerable excess, and the mixture agitated, as long as any gas was produced.

The soils were frequently subjected to two other processes, for the purpose of comparing results. After the action in the pneumatic apparatus was over, the carbonate of lime was separated, in the mode prescribed by Davy, and the weight ascertained. Its impurity was then proved, by throwing it into diluted sulphuric acid. By uniting with this acid, the magnesia (if any,) forms Epsom salts, the clay forms alum, and the lime becomes gypsum. The last alone being insoluble, may be separated in a solid form, from the other salts, and the vegetable extract. Sulphuric acid is far from an accurate test for carbonate of lime; but it is enough so, to confirm the first process, and to shew that no reliance can be placed on the second, which is generally resorted to for this purpose.

The following examinations are of soils which are well known, and present every different character which this district furnishes. The specimens were all taken from places, which are supposed never to have been manured, and when any are described as retentive of manure, or otherwise, the inference is drawn from its effects on adjoining and similar soils.

1. Rich black loam, from the top of the bluff at Coggin's Point, containing muscle shells throughout. Long under exhausting cultivation. 1000 grains, cleared of all the coarse shelly matter (as it can have no effect on the soil, until finely divided,) gave, 16 ounce measures of carbonic acid gas, equal to 32 grains of carbonate of lime.

2. 1000 grains of similar soil, from another part of the same field, gave,

By measurement of gas, 24 grs. of carbonate of [lime.
By precipitation (according to Davy's Ag. Chem.) 31
By sulphuric acid, 29

For the amount of carbonate of lime obtained by the last process, I take two thirds of the quantity of sulphate of lime formed.

3. Soil of an island containing about 5 acres of level dry land, lying at the end of Coggin's Point, and surrounded by the river, and tide marsh. The east end, dark brown shelly loam, capable of producing 35 bushels of corn per acre. The shells and value of the land decrease together, as the west end is approached, where shells are seen but in a few small spots, and the product about 12 or 14 bushels. Sorrel thinly scattered over the poorest part. Long under exhausting cultivation.

1000 grains of soil from the east end, gave—

Of coarse shelly matter (separated by hand,) 8 grs.
Of finely divided carbonate of lime, 82

1000 grains from the west end, taken from one of the spots shewing shells, gave—

Of coarse shelly matter, about, 1 grain.
finely divided carbonate of lime, by measurement of gas, 1½
by precipitation, 5
Difference, 3½

4. Soil from Eppes' Island—dark coloured, rich clay loam—the arable land very much reduced by a long course of the three shift system, but is still considered of the first quality.

To 1000 grains of soil, I added 3 grains of pure chalk, they gave 1¼ oz. measures of gas—equal

To carbonate of lime, 2¼ grs.
do. by precipitation, 17
do. by sulphuric acid, 4
known quantity, 3

The true result by the measurement of gas, deducted from the known quantity added, shews a loss of half a grain, and that the soil contained no carbonate of lime.

5. Soil from Edward H. Neblett's land—part of an extensive body of similar quality lying between Powell's creek and Ward's creek: very poor, stiff, light coloured clay. Contained no carbonate of lime.

6. Soil from another large tract of poor land in this county, lying between Otter-dam swamp, and the head waters of Ward's creek. Close and stiff, from the fineness of the sand, of which the soil is mostly formed; remarkable for producing large and excellent pine timber. Contains no carbonate of lime.

7. Soil from Richard Cocke's land, Surry, between Black water and Otter-dam swamp—close, poor, and sandy. 1000 grains gave—

Carbonate of lime, by measurement of gas, none.
by precipitation, 7 grs.
by sulphuric acid, about ¼

8. Soil from Eldridge Blunt's land, Sussex, a mile south of Black water; light and poor. 1000 grains gave—

Carbonate of lime, by measurement of gas, none.
by precipitation, 6 grs.
by sulphuric acid, none.

9. The three following specimens were taken from land cleared within a few years, and not more than 100 yards apart. They shew the characters of the remarkable strip of land, lying between the high hills and James' river, and extending nearly from Bailey's creek to Powell's creek. Soil generally light, rich and durable, but interspersed throughout with barren knolls of shelly sand, pure sand, (apparently,) and sometimes stiff clay.

1000 grains of the best soil gave, 1½ grains of carbonate of lime.

400 grains of poor sandy soil in which some particles of shelly matter were visible—gave 87 grains of carbonate of lime—near 22 per cent. I have used sand less calcareous than this, as manure, with good effect.

To 1500 grains of poor clay soil, near the two last, I added 29 grains of pure chalk, and obtained of carbonate of lime, 28 grains
Known quantity, 29
1 g. loss; soil contain'd none.

10. 1000 grains of poor stiff soil from Green Spring, James City county, gave no carbonate of lime.

11. Soil of the best quality, from the neighbourhood of Huntsville, Alabama; brown, or chocolate colour, and uncommonly friable and light, though containing very little sand.

To 1080 grains of soil, I added 6 of pure chalk, &

obtained by measurement of gas,	8½ grs. carb. lime.
Add the usual average loss,	2
	10½
Deduct the known quantity previously added,	6
Quantity present,	4½ grains.

The solution precipitated gave of carb. of lime, (or solid matter,) 73 grains.

I was prepared to expect in our soils, a very small quantity of calcareous earth, compared to those of Europe, of which analyses have been published; the deficiency, however, proved to be still more general, than was expected. Among all the soils, analysed and described by Kirwan, Davy and Rozier, I believe not one is stated to be entirely destitute of carbonate of lime, and the average proportion contained, is very seldom equalled by any in this country. Here, not an atom is present in more than nine-tenths of our soils. This remarkable difference in constitution, proves (even to those who may attach no value to my views of the subject,) that the same modes of improvement cannot be applicable to both—and that if calcareous manures are serviceable in England and France, they must be far more beneficial in Virginia.

Many other examinations of various descriptions, concur with those stated above, in the following important results: 1st, that all soils containing any quantity of carbonate of lime, not exceeding 10 per cent, are durably fertile—and, 2ndly, that every soil naturally poor, is entirely destitute of carbonate of lime, excepting the very few cases, in which the proportion is so excessive as to cause sterility. So far, facts completely support the theory of the constitution of fertile soils, and exhibit the general cause, and the complete, if not the only remedy for sterlity. But there is an apparent and striking contradiction, in the many rich soils which are as destitute of *carbonate* of lime, as the poorest. This difficulty will be explained, when that particular class comes under consideration. It is first necessary to arrange soils according to their composition, and to treat of each class, under its proper head: all may be properly distributed among the four classes, which I shall call, *calcareous, super-calcareous, acid,* and *neutral soils.*

Calcareous Soils.

To this class belong all soils which contain finely divided carbonate of lime, but not enough to injure their productiveness. They are dark coloured, friable, rich in their natural state, durable, and retentive of animal and vegetable manures. The growth of wild locust is almost confined to soils of this class, and after cultivation, they always throw up white clover in abundance.

Super-calcareous Soils.

In these, the quantity of carbonate of lime is so great as to injure or destroy their powers of production. They can only be improved by applying siliceous sand or clay and vegetable manures, in qantities sufficient to reduce the proportion of calcareous earth, to the standard of fertility. This would be so expensive, that such soils may be considered al most unimproveable.

What proportion of calcareous earth will cause sterility, must depend on the nature of the other ingredients of the soil, the inclination of the surface, and the quantity of water which it is accustomed to receive. The sand of the desert which has covered and destroyed so much of the fertile land of Egypt, is said to be almost entirely composed of carbonate of lime. Rain scarcely ever occurs in that country: but whenever water is conveyed to these naked sands, by irrigation, they immediately become highly productive.

Why a large proportion of carbonate of lime, should cause sterility, is not very evident, nor would the inquiry be of much importance. 'Tis enough that we know such to be its effect. Soils of this class are very rare in this country, but in many parts of the old world, they are so common, as to induce my belief, that the excess of calcareous earth is as much the cause of sterility there, as its deficiency with us.—Most of the barren plains of England, are composed principally of chalk; and it appears from Rozier, that such soils are still more common in France—to which country, I presume, his remarks should be applied, though he makes no such limitation. He divides soils into three grades, according to their value and states their composition to be as follows:

1st quality,—10 parts composed of	carbonate of lime	1
	pure clay	6
	siliceous sand	2
	vegetable earth	1
		10
2d quality,—carbonate of lime		2½
clay		4
siliceous sand		3
vegetable earth		½
		10
3d quality,	carbonate of lime	5
	clay	1
	siliceous sand	4
		10

And a very small proportion of vegetable earth.

This statement of Rozier's is doubtless well founded, as far as his observations extended, and according to his estimate, the least productive of the soils, he enumerates, contain 50 per cent of calcareous earth. It is then not to be wondered at, that chemists should never have suspected fertility to be caused by the very substance, which was found most plenty in barren soils. The proportion which Rozier assigns to the best soils, (10 per cent.) agrees with the results of my examinations, though I have but seldom found as much.

Acid Soils.

The soils which belong to this class, contain an excess of vegetable acid, above the quantity necessary to combine with the small quantity of lime which may be present: of course they have no *carbonate* of lime. Such soils only produce in abundance, the acid plants, pine, whortleberry, sorrel, (*rumex acetosa*) and broom grass.§ They are naturally poor, and incapable of receiving durable improvement, except from calcareous manures.

I have advanced no opinion which is less supported by authority, or to which stronger opposition may be expected, than the supposition of acidity being a common ingredient of soils. The term *sour soil*, is frequently used by farmers and writers on agriculture, but so loosely and with a meaning so indefinite as to deserve no consideration. Of those who really mean what the word conveys, there are but few who speak of acid in earth. Darwin and Dickson suppose sulphuric acid to be present in certain *clays*; both, most probably, on the authority of Morveau, who detected it by chemical analysis. Davy says that the same acid is found in peat, (a kind of vegetable soil not found here,) but with this single exception, does not name any kind of acid, nor any compound of vegetable acids, in his enumeration of all the substances, contained in soils. Dickson, also, slightly mentions "other acids" besides the sulphuric, but without stating their kind, or his reasons for believing in their existence: it is not necessary, however, to discuss opinions on this subject, when advanced by an author who is capable of recommending gypsum for the purpose of neutralizing acids.

Dundonald, alone, supposes vegetable acids to be abundantly formed in soils, and by uniting with the calcareous earth present, to form salts of lime. According to this author, these effects are produced in the following manner—Oxygen, which is one of the ingredients of atmospheric air, has a tendency to unite with all vegetable substances. When dead vegetables are exposed on the surface of the earth, they become *oxygenated*, or combined with a small proportion of oxygen, which makes them incapable of rotting, or of rendering any service to soil or vegetation. By uniting with more oxygen, the oxalic acid will be produced, which becomes oxalate of lime, by combining with the lime in the soil. It follows from this reasoning of Dundonald's, that this process must continue as long as there is vegetable matter, to be acted on, and after all the calcareous earth is taken up free acid will form, and remain in the soil, until neutralized by calcareous manures.

This theory of oxygenation, if it could be relied on as correct, would discover sources of vegetable acid operating at all times, and in all places But it seems to prove too much, to be altogether true. Had such been the action of the atmosphere on the surface of the earth, every particle of vegetable matter must have become either insoluble or acid, and not a spot could have escaped being reduced to absolute sterility. Though this work was published more than twenty years ago, I have never seen in any of later date, the slightest notice of this theory: the oxalate of lime which it makes an ingredient so universal in soils, is not mentioned as such by Kirwan or Davy, and Dundonald himself does not state that he ever detected it by analysis. But for the tacit denial, by all later writers, of the presence of vegetable acid or its compounds in soil, my task would be only to apply Dundonald's discovery to the peculiarities of our soils. As it is, I shall offer some additional reasons, which alone appear to me, sufficient to prove the existence of acid soils.

Grisenthwaite, the latest writer on agricultural chemistry, has the following passage, in his 'New Theory of Agriculture.' "Chalk has been recommended, as a substance calculated to correct the sourness of land. It would surely have been a wise practice to have previously ascertained the certainty of this existence of acid, and to have determined its nature, in order that it might be effectually removed. The fact really is, that no soil was ever yet found to contain any notable quantity of acid. The acetic and carbonic are the only two that are likely to be generated by any spontaneous decomposition of animal or vegetable bodies, and neither of these have any fixity when exposed to the air."—This is probably correct, as a mere chemical fact. I certainly have never examined a soil containing enough uncombined acid, to be detected by the usual tests. But still the term *acid* will be applied with propriety to soils, in which growing vegetables continually receive it from the decomposition of others, (for which no '*fixity*' is necessary,) or in which acid exists *combined* with some base, which readily yields it to growing plants, to be thus quickened or retarded, according to their kind. It will be sufficient for me, if I can shew, that certain soils contain some substance, or possess some property, which promotes exclusively, the growth of acid plants—that this cause is increased, by adding known vegetable acids to the soil—and is totally removed, and can only be removed, by the application of alkaline manures, which destroy all acids. Leaving it to chemists to determine the nature and properties of this substance, I merely contend for its existence; and from whatsoever cause these effects may be produced, for the want of a more appropriate name, I shall call that cause, *acidity.*

All soils of this description, however unproductive when under cultivation, produce a luxuriant growth of pine and whortleberry before they are prepared for the plough, and sorrel and broom grass afterwards. These plants never thrive on calcareous soils Pines are rarely, if ever seen on the rich lands of the Western States, while their number and size are remarkable on the barrens of the Carolinas.—I have had no opportunity of examining these soils—but fear not to

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* *Cours Complet d'Agriculture, par l'Abbe Rozier.*

§Pine, sorrel, and at least one species of whortleberry, are sour to the taste—this quality in broom grass, rests on conjecture. A remarkable exception to the rule above stated, is found in the acid plant, vulgarly called *horse sorrel*, (*oxalis acetocella*) which prefers soils the most unlike in quality to this class, and I have seen it on a soil calcareous to excess. It is probable that this plant draws its acid entirely from the atmosphere, and the others from the earth.

assert, that the first contain calcareous earth, and that the last are totally without.

One vegetable acid will feed plants producing other kinds; thus pine leaves, and oak wood produce sorrel, and I have heard that pomace (which certainly is a poison to valuable plants,) has similar effects. Peat and fossil coal contain sulphuric, and perhaps vegetable acid; and Dundonald says, that a growth of sorrel is the invariable consequence, when either of these substances has been applied as manure. Farm-yard manure, which gives out acetic acid when decomposing, will encourage the growth of sorrel more than any other plant, if the soil to which it is applied is not immediately cultivated, and is not calcareous. Cultivation immediately following manuringwill of course, prevent the growth of sorrel, but does not diminish its cause, which still inflicts its evil effects on the crop. It is well known that all decomposing vegetable matter gives out acid, and as it is greedily seized and stored up, by acid plants, the natural process is made evident, by which this quality of soils, commences and continues.

An acid soil made artificially calcareous, by lime or shell marl, is thereby rendered incapable of producing sorrel or broom grass. On these facts I rest the proof of the existence of acid soils.

Much the greater part of the lands of lower Virginia are rendered unproductive by acidity, and generation after generation have toiled on them without being remunerated, and without suspecting that their land throughout, was even then as rich, as their few improved lots appeared to be. The cultivator of such soil, who knows not its peculiar disease, has no other prospect, than a gradual decrease of his present scanty crops: but if the evil is understood, and the means of its removal within his reach, he has reason to rejoice that his soil was so constituted, as to be preserved from the effects of his own improvidence and that of his forefathers. The presence of acid, by restraining the productive power of the soil, has in a great measure, saved it from exhaustion; and after a course of cropping, which would have utterly ruined more productive lands, the powers of our soils remain scarcely impaired, and ready to be called into action at will, by the use of calcareous manures. If an English agriculturist was asked, what would be the effect of 50 years continued and severe cropping & close grazing, without manure, his answer would certainly be, that such a course could not fail to be followed by complete and hopeless sterility. Yet *we* know instances enough, where such has been the practice, on soils never productive, and which however damaged, still continue under cultivation. In other countries, the existence of soils which were incapable of being either improved or exhausted, to any considerable extent, would justly be considered a fact so remarkable, as to merit all the labour of investigation, which it might require. Here, its frequency causes it to be unnoticed; and they who seek improvement, continue to obey rules drawn from English agriculturists, on soils to which England furnishes no parallel.

Neutral Soils

Neutral soils are such as contain neither acid nor lime, or in which the quantities of both are so nearly equal, as to combine and leave no excess, of either, sufficient to produce perceptible effects. Soils of this class, are poor or rich, according as calcareous matter is entirely wanting, or is present though combined with acid, and the qualities of both thus neutralized.

All soils belonging to the three other classes, fully accord with the theory of their constitution and fertility: but the class of neutral soils appears at first view, in direct opposition to the principles which I have advanced, as they are frequently rich and durable, in the highest degree, and yet found by analysis, to contain not the smallest proportion of carbonate of lime. This difficulty may be removed by paying that attention to the properties of the different substances in soils, which is requisite for the full comprehension of the subject.

This apparent contradiction may be produced by one of two different causes, either of which will serve for its explanation. *First*—if no *compound of lime* exists in a fertile soil, its place must have been supplied by some other substance, of equal value. I have never asserted that *carbonate* of lime is the only cause of permanent fertility; on the contrary, phosphate and sulphate of lime were named as probable agents for producing the same effect, and many other substances may promote the same end, whose presence or combinations are as yet unknown, and which if known, might be beyond our control, for the purposes of improvement. Even if such was the case, it would not effect the truth of my reasoning: and for all practical uses, it is enough if I have pointed out *one* substance, which will change barrenness to fertility, and which may be cheaply applied to any extent required.

Secondly—Neutral soils, may (as stated in their definition) contain calcareous matter sufficient to have caused durable fertility, but exceeded in quantity and now neutralized in its effects, by vegetable acid. If it is not denied that soils receive acid from the decomposition of plants, it must also be admitted that as fast as it forms, the carbonate of lime present, will be decomposed, and a new compound formed. As this process must continue slowly to operate as long as the land remains uncultivated, the carbonate of lime, if not very abundant, will at last entirely disappear, and the soil loose every mark of having been calcareous, excepting its previously acquired fertility. The salt of lime thus formed, is probably as durable a manure, as the carbonate; but its character and action are different, nor can it be detected in soil, by the means most proper for the other. The quantity of acid in any particular soil, is far from invariable: it is increased by the growth of all plants which delight in its presence, and by the decomposition of vegetable mauures of every description; for this reason the longer a field remains at rest, and ungrazed, the more acid it becomes; and this evil keeping pace with the benefit, is the cause of enclosing so frequently producing no apparent improvement. Cultivation lessens the quantity of acid, by exposing it to be carried off by air and water, and by cutting off the source of its supply. In several instances, after one or other of these causes of acidity, I have had crops greatly injured by sorrel, which afterwards disappeared, and left the soils as they were before, productive.

That neutral soils contain lime in some other form than the carbonate, does not rest on mere conjecture. Some evidence is furnished by the mode prescribed by Davy for detecting carbonate of lime in soils; and the fact is fully proved by the analysis of ashes. Reasons have been offered to shew that the former process is completely inadequate for fixing the proportion of carbonate of lime; but this impure precipitate certainly contains a part of the compound of lime and vegetable acid; and this compound is generally, if not always, changed to *carbonate* of lime, by having been dissolved, and then precipitated. For example:—a rich and durable alluvial soil, which was carefully examined for the purpose of ascertaining this fact, furnished the following results:

1000 grains acted on by muriatic acid in the pneumatic apparatus, evolved no gas, and therefore, could have contained no carbonate of lime.	—
The precipitate obtained from the same, *well washed* and dried, weighed	16 gr.
Then subjected to the action of sulphuric acid, in the pneumatic apparatus, it yielded 1½ oz measures of carbonic acid gas, indicating the presence of 3 grains of carbonate of lime.	3
The solid matter remaining undissolved by the sulphuric acid (sulphate of lime) weighed 3 grains indicating the carbonate of lime to have been	2

This process leaves no doubt, but that the soil contained some neutral salt, of which lime forms the base, but does not ascertain the full quantity. Were proper means employed to fix the quantity of this salt, I believe that its proportion would mark the actual productiveness of soils, as accurately, as the carbonate of lime shews their capacities for improvement. The precipitate, called carbonate of lime by Davy, may be obtained from all soils—but much more abundantly from rich neutral soils, than from any of the acid class. Among soils of the same class, but of different textures, that which contains most clay, will yield the heaviest precipitate; which induces the belief, that a part of its impurity is caused by alumina or pure clay.

All wood ashes contain carbonate of lime, though obtained from neutral or acid soils, as were the following specimens.

100 grains of ashes of a pine log heap, from an acid soil, contained 6½ grains of carbonate of lime.

100 grains of ashes of whortleberry roots from the same soil, gave of carbonate of lime,	4 grains.
Other salts of lime, or lime made caustic by burning,	4
Siliceous sand,	92
	100

100 grains of ashes of equal parts of the bark, heart and sap wood of an old locust, from the same soil, gave

Carbonate of lime,	51 grains.
Lime not carbonated,	18
Siliceous sand,	5
Magnesia,	2
Charcoal,	2
Potash and loss,	22
	100

100 grains of ashes of young locusts from a very rich neutral soil, gave

Carbonate of lime,	40 grains.
Lime not carbonated,	30

100 grains of ashes of young pines from an acid soil, gave

Carbonate of lime and Lime not carbonated,	15 grains.
Siliceous Sand,	78
Potash and loss	7
	100

As vegetables can only derive their calcareous ingredients from the soils on which they grow, these experiments establish the fact, that some small portion of lime is present in soil of every kind, though not containing a particle in that form, which alone, (according to chemists) we might expect to find it. Compounds of lime with vegetable acids, are decomposed by fire, and become carbonate of lime; and therefore, this substance is found in ashes, though not in the plants from which they were obtained, nor the soils on which they grew. It is probable that the whole difference between barren sub-soil and the mould above, is caused by trees drawing all the calcareous matter within their reach, and by their death, depositing it on the surface.

The results of the few examinations which I have made, do not confirm the opinion of Saussure, that ashes yield quantities of calcareous earth, somewhat proportioned to the quantities contained in the soils from which they were taken. But they shew in different plants, quantities suited to the soil, which each prefers. Thus, of three kinds of ashes from the same soil, those of pine gave 5½, of whortleberry 4, of locust 51 per cent, of carbonate of lime, and similar proportions of lime not combined with carbonic acid.

If phosphate of lime formed any considerable ingredient of soils, it might perhaps present results similar to those which distinguish the neutral class. But though the phosphate is contained in all wood ashes, and therefore in all soils, its quantity (according to Davy) is so small, that it cannot possibly be the salt in question. My supposition, that the lime is combined with some *vegetable* acid, rests on the facts stated with regard to acid soils.*

* Since this essay was read before the Agricultural Society of Prince George, I received seven specimens of *lime-stone* soils, carefully selected in the neighbourhood of Lexington, Va. Never having doubted the correctness of the received opinion, that all limestone soils were highly calcareous, I was

The Action of Calcareous Manures.

I shall next proceed to the inquiry, to what properties of carbonate of lime, its peculiar fertilizing effects are to be attributed; and if it can be made clear, that it has abundant powers for the purpose, of which the other two earths, clay and sand, are nearly or entirely destitute, there will be added another strong proof in support of the supposed constitution of fertile soils.

Sand has no chemical attraction for vegetable and animal manures, and readily yields them as soon as they are applied, to whatever has such attraction. Hence, sandy soils give out manure freely, not only to the growing crop, but to the sun, air, and water, so as quickly to lose the whole. Clay, by its closeness, mechanically excludes, what sand freely admits, and therefore gives out manure much more slowly than sand, whether for use, or for waste. This earth also exerts a slight chemical force in retaining manure, but too weak to enable such soils to become rich by natural means. Of this, our large tracts of very poor clay offer sufficient proof.

Calcareous earth has an attraction for oils superior to that of clay, † and will combine with any vegetable extract,‡ so as to render it less soluble, and consequently not subject to the waste, which would otherwise take place. This power of combining with the food of plants and fixing it in soils, from which it would otherwise be continually escaping, shew why calcareous land alone, should be capable of enriching itself, or of receiving durable improvement from artificial manures. Calcareous manures, in enriching soils, act precisely like the mordants, used in the process of dying—like alum, which gives no colour to the cloth, but is as indispensable as the dye itself, for the purpose of fixing it permanently. The power which this earth exerts, in binding manure to soils, does not however, (like clay) prevent the crop receiving the full and immediate benefit. Growing vegetables attract their food, still more strongly than does calcareous earth, and draw it from its state of combination, as freely as from sand. The principal means then, by which calcareous manures enrich, are, *giving up manures readily, for use, and completely preserving them from waste.* These benefits would not immediately be perceptible, but would continue to increase, until the vegetable matter accumulated in the soil, was equal to its power of retention.

The next most valuable property of carbonate of lime, for the improvement of soils, is that of neutralizing acid. Our poorest soils, when new, contain vegetable matter in abundance—perhaps to excess;—but their acidity counteracts their powers for production. A sufficient application of shell marl, or any other calcareous substance, destroys the acid, and allows the land, for the first time, to exert the power, which it actually possessed. This benefit is immediate; but though it may double the product of the soil, the calcareous matter has added nothing to its richness, nor can it, until it has both time and means, for accumulating and fixing vegetable matter. The salt of lime (whatever it may be) which is formed in this process, appears to be also a valuable manure, from the durability of the rich neutral soils, of which it is supposed to be an ingredient.

To these two properties, of destroying acids, and combining other manures with soils, I attribute the remarkable effects of carbonate of lime. It has several other fertilizing powers, which are equally well accounted for, from its known chemical properties. These will be hastily mentioned, though they are neither peculiar to calcareous earth, nor are their effects considerable enough, to add much to the productiveness of land.

Calcareous manures possess in common with clay, the property of making sandy soils more absorbent, and in common with sand, that of making clays more light and friable—but in a greater degree than either. By fixing vegetable matter, they make soils blacker, and consequently warmer. They may also form part of the nourishment of plants, as all take up some calcareous earth, and shells also furnish animal matter; but I have never been able to perceive any effect which could be attributed to this cause.

Carbonate of lime always contains 43 per cent. in weight, of carbonic acid, which differs from all others in being not only innoxious to growing plants, but is indispensable to their existence. As much of every vegetable as may be converted into charcoal, is wholly formed by the decomposition of this acid, which the leaves are continually absorbing from the atmosphere. From the large proportion of this necessary food of plants, contained by all calcareous manures, their good effects have been attributed, by some writers, to vegetables drawing from them a more plentiful supply. This effect cannot be of much importance, nor can it take place, unless some stronger acid is present in the soil, which by combining with the lime, leaves the carbonic acid free to perform the office ascribed to it. By no other means will it be discharged, and, therefore, they who maintain the reality and value of this action, are bound to admit the existence of acid soils.

The practical effects of Calcareous Manures.

It is scarcely necessary to prescribe rules for the proper application of calcareous manures, as their action and the nature of the soil, ought to direct our practice, and vary it according to circumstances. If the opinions which have been expressed are unfounded, it is evident, that the attempt to reduce them to practice, would most certainly shew their fallacy. These opinions direct us to expect both immediate and permanent benefit, from applying calcareous manures to acid soils—that on neutral soils the effects would be slow, gradual, and regularly increasing, as long as the soil is allowed to accumulate vegetable matter—and that on calcareous soils, the application would be either useless or injurious. On different soils of the same class, the greatest benefits must be looked for, where most vegetable or animal matter is present.—None of my experiments are of older date than four years back, and therefore are not decisive as to the ultimate effects of calcareous manures; but as far as they have gone, they have uniformly and fully sustained the theory by which they were directed.

My experiments have been confined to the use of carbonate of lime in that form which is so abundant throughout the lower part of this state—fossil shells mixed with earth, and commonly, though improperly, called *marl.* But the same effects would attend its use in any other form, as lime, (exclusive of its caustic and solvent qualities,) limestone gravel, chalk, ashes, &c. The proportion of carbonate of lime, in most of the bodies of shell marl, which I have used, is less than usual—but one stratum contains a very small quantity of *gypsum,* which it will be necessary to notice. Had the presence of gypsum not been discovered in this singular stratum, its effects would have caused very erroneous opinions as to the action of marl: an immediate, but transient benefit was generally produced by the gypsum, where the carbonate of lime was believed to have no effect, for several years

The following experiments will serve for a full and fair specimen, of all that I have made. I have marled altogether about 135 acres, including 40 of this year's work, not yet cultivated. Most of the circumstances stated, were noted at the time of their respective dates. The land, with such exceptions as may be mentioned, has been secured from grazing, since the year 1814, and was always marled on grass.

Experiment 1.—1818. New ground—poor acid soil; 2½ acres, covered at the rates of from 125 to 200 bushels per acre, with marl, (containing 33-100 of carbonate of lime.)

Result. In corn—supposed to be 40 per cent better than the rest. 1819. In wheat—the benefit as much or more. 1820. In natural grass not grazed—no difference in quantity. From the newness of the land, but little grass, and no sorrel as yet on the field.

1821. Marled it again, together with the adjoining land (11 acres in all) at the rate of 530 bushels of marl (37-100 carbonate of lime) per acre, and on a small part as much as 1000 bushels.

Result. In corn—the whole excellent for the season—the piece twice marled, better than the other, but the line of division, could not be distinguished as before. The spot covered most heavily, neither better nor worse for it.

Experiment 2.—Old cleared land near the last, and similar soil, but much exhausted—well dressed with vegetable manure in 1815, no trace of which remained. 1818—in 5½ feet beds, well ploughed September preceding. In March, spread unrotted farm-yard manure along the water-furrows, and on three beds, also scattered marl, (33-100) 390 bushels per acre. The beds immediately reversed, and afterwards planted in corn.

Result. But little benefit from the manure, and not the least from the marl; nor was any observed (or looked for,) in 1819 on grass, or in 1820 on wheat. 1821—In grass—a striking difference. In June, the strip could be distinguished to a line, by the almost total absence of sorrel, with which the adjoining land was covered, and by a luxuriant growth of bird-foot clover.

Experiment 3.—A quarter acre of rich neutral soil, covered with *gypseous* marl (53-100 carbonate of lime) at the rate of 250 bushels per acre. Ploughed deep and planted in corn.

Result. 1818—By July, the difference equalled 50 per cent, after which, the adjoining corn gained on the manured, until no difference could be perceived. 1819—in wheat—no difference. 1820—in grass—easy to be distinguished by the absence of sorrel, which on the rest, has been increasing from the time the field was inclosed. Its growth, (principally bird-foot clover,) also better. 1821—in grass—the difference much greater—its growth as luxuriant as I ever have seen of the same kind of grass, and thrice as good as on the rest The sorrel as before. The spring and early part of summer remarkably wet.

Experiment 4.—A strip of ¾ of an acre across the shelly island, marked 3 in the examinations of soils, covered at the rates of 200 and 500 bushels of muscle shell marl, (14-100.)

Result. 1819—in corn, and 1820 in wheat—no effect on either.

Experiment 5.—Another strip adjoining the last, covered with *gypseous* marl (53-100 of carbonate of lime,) at the rate of 250 bushels. The soil also shelly, and capable of producing 20 or 25 bushels of corn to the acre, but not quite as rich or as calcareous, as the preceding subject of experiment.

Result. 1819—in corn—advantage over the unmarled, more than 50 per cent. 1820—in wheat; not as much. 1821—in grass, pastured; thickly set with a natural growth of white clover, of which there is not so much on the other marled strip, and very little on the land not marled. The results of the three last experiments, shew that all the *immediate* effects were produced by the gypsum, and not by the calcareous ingredient of the marl.

Experiment 6.—February 1819; marled an acre of poor broom sedge old field, at the rate of 160 bushels; marl (33-100) hauled and spread wet, and very unequally distributed. The land not ploughed then or since.

Result. No effect in 1819. In 1820, perceived the broom grass to be thinner and weeds taking its place. 1821; well covered with weeds, and but little broom

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astonished to find six of these specimens, (five of rich and one of poor soil,) to belong to the *neutral* class, being completely destitute of carbonate of lime. The remaining specimen was from a fertile soil, but so thickly covered with lime-stone rock, as to be unfit for cultivation. Of this, 1000 grains contains one grain only, of carbonate of lime. Thus it appears that the remarkable deficiency of calcareous earth, which I thought peculiar to this alluvial district, extends even into the lime stone country, and perhaps through all America. I do not make this statement with the expectation of its being believed by those who are best acquainted with the European accounts of soils: but I hope it may induce others of undoubted ability, to pursue the investigation, and confirm the existence of this singular feature in most of the soils of this country. Perhaps no other single fact can lead to more important consequences to the science of Agriculture.

† Bergman's Table of Affinity.

‡ Agricultural Chemistry, page 164, Am. Ed.

grass remaining. The adjoining land, as before, is under an unmixed growth of broom-grass.

Experiment 7. Of a poor light field, on which manure had never lasted longer than two crops, 7 acres were marled (33-100) at the rate of only 90 bushels—part of the same also covered with rotted farm-yard manure.

Result. 1819—In corn; no certain benefit, except along a small part of the dividing line. 1820—In wheat; something better. 1821—In grass; the difference still greater, but more in the kinds of plants, than in their luxuriance. No visible benefit from marl on the part to which manure was added.

Ex. 8. Adjoining the last, 4 acres marled at the rate of 180 bushels, and part also well manured.

Result. 1819—In corn, the part not manured has an advantage of 40 or 50 per cent. over the adjoining land not marled. 1820, in wheat, and 1821 in grass—the difference does not appear to have increased as in the preceding. On the manured land, some perceptible effect from the marl.—The improvement from manure (which however was heavily applied,) still remains.

Experiment 9.—Six acres of new ground, marled at the rate of 350 bushels. Soil, a poor white clay,

Result. 1820 - First cultivation, in corn—from 50 to 75 per cent. apparent benefit, but the whole piece so unequal, that no correct estimate could be made. 1821. In wheat—the difference increased.

Ex. 10—Sixteen acres of poor, light and acid land, covered at the rate of 1000 bushels of marl, (varying from 33 to not more than 17 per cent. of carbonate of lime, and all the balance, coarse sand.) Last cultivated in corn in 1816, and being too poor to bring wheat, had remained at rest and enclosed, the succeeding three years. The marling ended at a marked line, which was laid off through land of equal quality, for the purpose of ascertaining the exact difference. Cultivation the same, in all respects.

Result. 1820—In corn. The benefit greater and more uniform, than in any of the preceding. Three half acres were measured of marled land, and as many adjoining them, not marled- the product of each as follows:

Land not marled.	bush.	pecks.		*Land marled.*	bu.	pks.
1st half acre	7	1	opposite & adj'ng	1st	12	2
2d do	7	1	. . .	2d	13	3¾
3d do	7	2½	. . .	3d	15	½

The average increase, 12 bus, and three pecks of shelled corn per acre, being nearly 100 per cent. The season good, and the whole crop excellent for the soil.—1821—In wheat—very much injured by the wetness of the season—the marled part more than twice as good as the rest, which scarcely paid for seed and labour.

Ex. 11. Nine acres adjoining the last, marled at the rate of 400 bushels. Soil better—marl, and times of cultivation the same.

Result. No difference could be perceived where this joined the heavier covering of the last.

Ex. 12. One side of the 10th experiment ended in a productive neutral soil, through which a line was staked, having equal land on each side.

Result. No difference either in the corn or wheat.

The three next experiments were made within the space of 150 yards, and on soils, which when in a state of nature, were precisely alike. They still differ in nothing but productiveness. The same may be said of the experiments marked 1 and 2, which were in the same field.

Ex. 13. Part of a level piece of new ground cleared January, 1821, marled at the rate of 600 bushels per acre, (37-100.) Soil—light loam; Pine, Oak and Whortleberry the principal natural growth.

Result—1821—In corn, 2,262 hills to the acre—On each side of the straight line on which the marle terminated, a piece 28 by 21 hills, was gathered, and (by a careful measurement) produced as follows:

588 corn-hills not marled, made 2 bushels of shelled corn, or 7¾ per acre.

588 hills, marled, made 4¼ bushels, or 16 3-8 per acre.

Ex. 14—March, 1821—An acre, in the middle of a piece, cleared in 1815, was covered with 500 bushels of sand containing 20-100 of carbonate of lime. This piece had before only borne one crop, (in 1818,) and therefore may be supposed to contain an abundance of rotted vegetable matter, and to be now in the highest state of productiveness, of which such a soil is capable. Four adjoining quarter acres, two within, and one on each side of the marling, produced as stated below. The land was supposed to be perfectly equal, but the growth of the corn shewed that there was a slight deterioration extending gradually across the ground, which affected the measurements in the same order as they are numbered.

Quarter acres not marled.	*Quarter acres marled.*
No. 1, 6 1-8 bushels adjoining	No. 2, 8 1-2 bushels
No. 4, 5 1-8 bushels adjoining	No. 3, 8 1-8 bushels
2) 11 1-4	2) 16 5-8
5 5-8 average, or 22 1-2 bushels per acre	8 5-16 average, or 33 1-4 bushels per acre

Ex. 15. Land cleared 25 years ago, and brought almost to the lowest state of exhaustion, of which a level and acid soil is capable. Cultivated in corn in 1815, since which time it has remained at rest and enclosed, but received one good ploughing in the fall of 1817. But little apparent improvement from this long respite, except where it is made evident by the application of marl. The effects were ascertained on adjoining, and equal land, on the crop of the present year.

A quarter acre, not marled, produced 2 1-8 bushels of corn.

A quarter acre marled, 5 5-8 bushels.

Of the 13th and 15th experiments, the difference was much greater in the quality than even in the quantities stated. The measurements were made in the ears, allowing two for one of shelled corn, and every nubbin thrown in. Not half the corn of the two pieces, not marled, were sound and fully made. The season has been more unfavorable to forward or good corn, than to indifferent and late—as no rain fell from the middle of July, to the first of September.

In the spring of 1819, Mr. Thomas Cocke, of Aberdeen, marled some acres of a poor acid field, which had been always *close grazed*, when not under cultivation. The marl contained 40-100 of carbonate of lime, and was laid on at the rate of 500 bushels per acre. The piece included both stiff and light soil.

Result—The succeeding corn and wheat crops were benefitted but slightly, supposed to be about 15 or 20 per cent.—Since pastured, and the marled part is now (August,) grazed quite bare to its limits, whilst the surrounding land has a considerable cover of grass, which the cattle have rejected.

The following facts were formerly referred to, as the only known proofs of the value of shell marl, as a durable manure.

Three small pieces of poor land, neither exceeding 30 yards square, were marled by Mr. Thomas Cocke, 18 years ago. The rate not known, but the present appearance shews that it was very thick. The land before and since, grazed when not under a crop, and never manured. Very little benefit was perceived, until long after it had ceased to be looked for. During the last four years, (which is as long as I have observed them,) two of the pieces, one stiff and the other light, have produced at least twice as much grain as the surrounding land: the third piece, which is on a light hill side, is ruined by the application.

At Spring Garden, in Surrey, 10 or 12 acres of poor light land were marled 45 years ago. The farm, previous to the last nine years, was under the then usual *two shift* system—that is, cultivated in corn every other year, followed by wheat, wherever it was worth sowing, and close grazed during the short interval of *rest*, between wheat harvest, and the next winter's ploughing for corn. Since then, it has been enclosed, judiciously cultivated, and is improving throughout. Mr. Francis Ruffin, the present proprietor, shewed me this field in January, 1819, then under grass, and even at that time of the year, I could easily discover the commencement of the marling by the difference in growth: the improvement, however, was not perceptible throughout the piece. No certain information has been obtained of the effects, during the first 25 years. Mr. R. states that he remembers the marled land to have been generally seeded with wheat, and the surrounding land left out on account of its poverty; and that this difference of treatment sometimes extended to the crop of corn. He thinks that the difference of production, when the season has been very favourable, is but small—but is remarkable when the season is bad, as the marled piece is but slightly affected, when the other is most injured by wet or dry weather. Still, candour requires that I should add, that Mr. R. though devoted to the improvement of his farm, does not consider the profits from marl sufficient to induce his adoption of its use. So different are the conclusions, which may be drawn from the same facts.

An experiment at Banacond, near 50 years old, was not known to have been made, until 1819, when it was brought to light by the old negro who had carted out the marl. This piece is near an acre, in the middle of a poor field, and was so much better than the rest (though the cause was not then suspected,) as to receive no part of a dressing of farm-yard manure, which was applied to all the surrounding land, eight years ago. Notwithstanding this manuring, the adjoining land is not equal by more than half, to that which had marl alone. This field, like the rest of the farm, was under exhausting cultivation, until it was enclosed in 1813.

Though we have no information of the early effects, of the oldest of these experiments, yet there is little question of their being inconsiderable. In no instance was the practice judged profitable enough to be continued. The experimenters expected shell-marl to shew effects like dung, and their close grazing prevented its proper action being seen. They were therefore compelled to believe, that it was not worth using. At this time, however, these experiments shew such results, as to prove completely, the permanency of this manure. Had the system of cultivation pursued subsequent to the application, been meliorating, instead of exhausting, the superiority of the marled land would have been increased in proportion.

We have abundant proof of the durability of calcareous manure, from its common application in another form, so different from shell marl, that it seems not to be suspected, that the properties and action of the two substances are precisely the same. 'Tis a common saying, that "land never forgets where an old settlement once stood," and this well known improvement is entirely owing to calcareous manure. The land around an old dwelling, is always manured (whether intentionally or not,) with wood ashes, which, from their composition, may be correctly called *artificial marl*. Drawn ashes and shell marl are composed of exactly the same ingredients, except that the former contains also some phosphate of lime. I admit that old settlements must be also enriched by animal manure: but that, alone, an acid soil would soon "*forget*," as we continually see proved by the fleeting benefits of our summer cow-pens.

The quantity of carbonate of lime taken up by any crop, from an acre of land, has been ascertained (says Dundonald) not to exceed 80 lbs. in weight. As this is the only passage by which it can escape, a good covering of shell marl would not, at this rate, be all drawn from the land, by 200 successive crops. But though no renewal of marl may ever be required, it would not prevent the soil being exhausted of its vegetable matter, and thus utterly ruined by continued severe cropping. For the improving farmer, no means can be more effectual than the shell marl. But if the usual exhausting course continues to be pursued, though calcareous manures might for a long time increase the crops, yet their ultimate and certain result, would be the complete exhaustion of the soil, by its freely yielding supplies to vegetation, which its former acidity would have withheld.

It was stated, that from the properties of calcareous manures, they must be most beneficial on such soils, as are stored with the greatest quantity of ve-

getable manure. But the foregoing experiments shew, that though such is the case, when the vegetable matter is derived from enclosing, yet marl has had little or no visible effect, when combined with an application of animal or vegetable manure. Vegetable matter accumulated in a poor soil by enclosing, contains as much of acid, as of the food of plants; and it is by removing the evil, that marl produces so much immediate effect. The acid of farm yard manure, is of small amount, compared with its soluble nutritious matter. As calcareous manure increases production only by indirect means, its immediate effects must bear a certain proportion to the previous powers of the soil. Suppose it to increase the first crop 100 per cent. on an acid soil in the best state, and as much on another, ruined by exhaustion: in the first case, the increase might amount to 15 bushels of corn per acre, and in the last, to not more than two or three bushels. Marl alone, applied to a naked gall, would never improve it. The immediate effects of animal and vegetable manures are very different, as they bear no proportion to the state of the soil, and are most striking on the poorest. 'Tis possible to raise 50 bushels of corn from an acre of the most steril land, by a wasteful application of these manures, which directly furnish the food of plants. The evident consequence of these different kinds of action, is, that the immediate benefit of marl would be exceeded, and in a great degree concealed, by other manures applied at the same time, although the durable effects of both, might be most profitably secured, by their union.

My applications of shell marl have been in general much heavier, than I consider advisable. Wishing to ascertain its full power, heavy dressings were laid on, that no renewal might ever be wanting, and that whatever improvement might be gained from vegetable matter, there should be always enough of the calcareous to secure it. This course is best for experiment—but its action and power once known, it is more economical to apply it in quantities as small as will suffice to neutralize the acid, and give the soil a slight capacity for improvement, and to repeat it, as the accumulation of vegetable matter may require, until the soil arrives at the highest state of productiveness.

The labour required for using shell marl, is now the greatest obstacle to the practice, even with some of those, who from observing the whole progress of my experiments, are well satisfied that I have not overrated the benefits derived. It is held as shewing but little prudence, to expend on the marling an acre of land, more than the price at which it could have been sold. The previous value of the land has no bearing on the question, nor indeed has the expence per acre. If by laying out $100 on an acre of poor land, it would produce annually for ever, an increased clear profit of only $10, it would be a highly profitable investment. I have carefully, and with all possible accuracy, estimated the cost of two considerable pieces of marling. The first of nine acres (the experiment marked 10) cost $10 per acre for digging, hauling and spreading, at the then high prices of provisions and labour. The increase of the first crop averaged 12 bushels and 3 pecks per acre, which if it had sold at the price which was usual in 1819, when the marl was applied, ($3 50 per barrel,) would have nearly paid the whole expense, by the increase of the first crop. The marling of 20 acres this year (from a pit which requires uncommon labour,) at the average hauling distance of 635 yards, and at the rate of 665 bushels per acre, cost $8 88, or 18 cents the cubic yard of 20 3-16 bushels. Should the land be benefitted, as much as my experience gives me a right to expect, the increase of the first two crops, will repay the whole cost, even at the present low prices of grain. In some other cases, where the distance was small, and the digging easy, the expence was as low as $4 per acre. I would be much pleased to see exhibited a correct estimate of the expense of making and applying farm yard manure, and its full return on acid soils. The calculation, I fancy, would present results very different from the foregoing, and such as would astonish all who consider the practice profitable.

A great mass of matter on marl and other calcareous manures, is contained in English agricultural works; but though much correct information is given, its value is lost, by being confounded with a greater number of statements, which are loose, contradictory or false. To discriminate between the truths and errors of these works, would require a previous acquaintance with the subject, surpassing that of most of their authors. In some parts of England, any pure clay is called marl, and even some writers who treat of this manure, leave us to doubt, whether they would not define it in the same way. The county of Norfolk, in England, has been brought from a poor, blowing sand, to a high state of productiveness, principally by the use of marl: but the action was directly the reverse of marling in this country. The sands of Norfolk contained calcareous matter in abundance,* and I should therefore attribute their barrenness to the excess. The clay marl used, though containing some calcareous earth, actually served to diminish, instead of increasing the excessive proportion of the soil, at the same time that its clay gave the tenacity which was wanting. With the same views, Dickson very properly recommends clay marl for the improvement of chalk soils. The authors on whose knowledge and accuracy we can fully rely, when they mention the effects of marl, omit to inform us how much of calcareous matter may be present, in either the manure, or the soil, (both of which 'tis essential should be known,) and their readers are left to guess in what manner the operation is produced. Davy states as a general rule, that all soils which are deficient of calcareous earth, require such manures; and this simple proposition (which he appears to consider so self-evident as to require no proof,) conveys more of instruction and truth, than the whole body of English authorities on this subject, taken together.

When I first recommended the use of shell marl, in 1818, no information whatever, of the practice had been given to the public, nor was it known to us in this neighbourhood, that any other experiments had been made in the United States, than the very few of a prior date which I have stated. Since, however, I have learned that the value of this manure, was practically known in the counties of King William and James City; and in the latter, its use is now rapidly extending. I have made several attempts to procure from different farmers of these counties, some account of the effects experienced—but without success, or even the least encouragement to continue such inquiries. It appears from some general notices in the newspapers, that shell marl is used extensively in New Jersey. Two very valuable papers on this subject have since been published. The first of these is Mr. Singleton's letter "On Shell Marl," (in the 4th volume of Memoirs of the Agricultural Society of Philadelphia,) which gives testimony to the worth of this manure, from a very intelligent farmer, who has used it longer, and to greater extent, than any other in the United States. The other is Dr Black's essay, "On the intrinsic value of land," published in the second volume of the American Farmer. This essay may at first be thought to contradict rather than sustain my opinions, as the author speaks so slightingly of marl, as no way tends to encourage its use. This seeming contradiction is only a striking example of the necessity of attending to the *properties* of manures, without regarding their *names*. Dr. Black's plan of improvement is founded on the use of *lime* which he considers essential to the object in view. Caustic lime has powers entirely different from mild lime, and of which I have not spoken, as they are not connected with my subject: but that essay informs us, that the author does not look for the benefit from lime in the first crop, and it is certain, that it must become *carbonated*, and its caustic action cease, before the second year. We must therefore attribute nearly, if not quite all the benefits which Dr. Black has thus derived, to carbonated or mild lime, which has precisely the same properties with shell marl; and the whole argument in favour of caustic lime, goes in support of the carbonate.

When opinions are advanced which are either unsupported by, or directly opposed to those most generally received, it is highly necessary to state them as clearly and distinctly as possible. Such has been my object throughout this essay;—every less important requisite of composition, has been sacrificed for the sake of perspicuity, and perhaps I may thus have subjected myself to other charges, besides that of being tedious. In no other respect, however, do I offer any apology, nor ask favour or forbearance towards the opinions presented. If my views are well founded, they deserve consideration: if erroneous, it is proper that they should be fully exposed, and none will see their errors corrected, more willingly than myself.

EDMUND RUFFIN.

Coggin's Point, Oct. 7th, 1821.

* Kirwan on Manures.

Explanations of terms used in the foregoing Essay, necessary to the right understanding of the author's argument, by persons who are not familiarly acquainted with Chemical expressions.

Acids—Bodies are so called if sour to the taste. They turn vegetable blue dyes red; they mix freely with water, and are generally formed by the union of a known base, such as sulphur, with portions of pure air or oxygen: *see* sulphuric and other acids.

Acetic Acid, is vinegar highly purified, or concentrated by distillation.

Affinity, or Attraction, is the disposition of bodies to combine—thus water dissolves or combines with salt, which it would leave in order to unite with spirit of wine.

Alkalies, are volatile or fixed; the volatile evaporates when exposed to the air, and is often seen in the form of Hartshorn used to prevent fainting—the fixed alkalies are pot-ash: obtained by evaporating water which had been drawn thro' common wood ashes—and soda, obtained by evaporating water which had been drawn through the ashes of vegetables which grew on the sea shores.

Alum, consists of pure clay or Alumina, a little pot-ash, sulphuric acid and water.

Alumina, is the earthy base of Alum—and hence called Alumina—it is that body which gives to clays their peculiar properties—heat which expands most bodies diminishes the bulk of clay—it is the chief material of China and stone ware.

Base, is a term used to denote the earth, the alkalie, or metal of which a salt or acid is formed: thus Alumina is the base to which we add sulphuric acid when we would form Alum; and sulphur, the base to which we unite oxygen or pure air, to form sulphuric acid.

Calcareous Manures, are mixtures of sand and clay, with lime in the form of decayed sea-shells or chalk—these we call Marl; or they are chalk or lime, usually in the shape of carbonate of lime.

Carbonate of Lime, occurs in the form of chalk, marble, lime-stone, sea-shells, &c. and when either of these are kept for some time in a white heat, the carboic-acid is disengaged or driven off—leaving them in the form of quick or caustic lime, as used to make mortar—it is to the power and disposition of this caustic or quick lime, to unite again with carbonic-acid and to solidify water, that mortar becomes hard.

Carbonate of Pot Ash, is formed by the union of carbonic acid, with the pot ash of commerce, which contains only half the quantity of carbonic acid found in carbonate of pot ash.

Carbonic Acid, is obtained only in an aerial form—it has not yet been condensed like other acids, into a liquid—it is created by fermentation, by combustion, or respiration—it extinguishes flame and life—it may be procured by distilling sulphuric acid on chalk. The sulphuric acid, displaces and frees the carbonic, and uniting with the chalk, forms gypsum, or plaster of paris.

Caustic Lime becomes mild or carbonated, by combining with carbonic acid, found in the air or soils, as it does when it becomes air-slacked, and loses its power to produce heat if exposed to water.

Chalk—100 parts usually contain 57 parts of lime, and 43 parts of carbonic acid.

Clay, is the earthy base of alum, called *Alumina*, mixed with more or less *Silex*, or flinty sand; and sometimes has magnesia or lime in it.

Epsom Salts, were produced originally by evaporating the water of Springs at Epsom, in England—these salts consist of sulphuric acid and magnesia—they exist in Sea Water, and are found in solution, when the common, culinary salt has crystalized, after a large part of the water has been evaporated.

Gas, is a term which includes all the airs that differ in their properties from the air of the Atmosphere, and this is composed of three Gases—OXYGEN, or pure air, the support of life and combustion—AZOTE, or impure air, the basis of nitric acid, which united to pot ash, forms Salt Petre—and CARBONIC ACID GAS. Water is formed of two Gases—oxygen or pure air; and hydrogen or inflamable air, the cause of flame.

Gypsum, or Plaster of Paris—contains 43 parts sulphuric acid, 33 parts lime, and 24 parts water in the 100—it is soluble in 460 parts of water at a temperature of 60°

Loam, may be considered a clay of loose or friable consistency, mixed with *mica* or isinglass, and iron-ochre.

Magnesia—as known in commerce, contains 34 parts carbonic acid, 45 parts magnesia, and 21 parts water—it exists in sea water, connected with sulphuric acid, and may be obtained by adding potash, to which the sulphuric acid will unite, and thereby free the magnesia—it is almost insoluble in pure water, but will combine with and solidify it, as lime does, when we make this into mortar.

Marl, is a mixture of carbonate of lime, and clay, the varieties differ as they contain more or less lime, or sand, or the adhesive part of clay—on a clay soil, marl, abounding chiefly in lime and sand would be best—on a sandy soil, that which is not only rich in lime, but also in the tenacious part of clay, would be preferable.

Mordants, is a term which dyers use to designate the substances that are employed to dispose the colouring particles, to unite permanently and brilliantly, with the objects to be dyed.

Muriatic Acid, is obtained from sea salt, when combined with soda, they form our table or culinary salt—by pouring sulphuric acid on sea salt the muriatic acid is displaced, and the soda then uniting with the sulphuric acid forms the well known, useful, Glauber-salts.

Neutral Salts—are formed when acids unite with Alkalies, so as to disguise each others properties; thus SULPHURIC ACID, which is intensely sour, unites with SODA, or the alkali of sea-salt, which is corrosive, and Glauber salts, are the result of their union.

Oxalic Acid—is obtained in a crystaline form from Sugar, distilled with nitric-acid, and hence it has been called the Acid of Sugar—it exists in the wood-sorrel *oxalis acetosella*, diluted in much water it is pleasant, but concentrated—or mixed with but little water, it is very acrid.

Oxygen—100 parts of the atmosphere contain 21 parts of Oxygen gas or vital air—its presence is necessary to support life or combustion, and to the germination of seeds; all these must cease when it is absent—united to sulphur they form sulphuric acid—united with hydrogen gas they form water.

Oxygenated—we say a body becomes oxygenated when it unites with oxygen—thus iron combined with a certain portion of oxygen is black, and with a still greater portion becomes red or rusty.

Peat, or the black moss of moors, strictly speaking, is not found in many places, and no where so frequently as in Scotland and Ireland, where the bogs abound with, and afford it in great quantities for fuel.

Phosphate of Lime—is the basis of Bones, and consists of Lime 70 parts, and phosphoric acid 30 parts—this acid is found free in *onions*. Phosphorus may be obtained from burnt bones, by a complex process—and Oxygen, with this base, form Phosphoric-Acid.

Pneumatic Apparatus—this is designed to measure aireform fluids or gases—a very simple one is described and represented in Davy's Agricultural Chemistry; it consists of a bottle which holds the acid to be used—this bottle is closed at the upper end by a glass stopple, and it has a stop cock towards the other end, through which the acid may be passed at pleasure; this end is fitted into the neck of a larger bottle, into which the soil to be examined is placed, and from one side of which a tube passes, having an empty or flaccid bladder at its termination, within the neck of a larger vessel that is filled with water; so that when the acid has flowed upon the soil, the elastic fluid which it generates, passes thro' the tube, and dilates as it fills the bladder, which causes some of the water in this vessel to flow through a spout into a graduated measure, and by its volume indicates the proportion of gas disengaged; every ounce measure of Carbonic Acid Gas, indicates the presence of 2 grains of Carbonate of Lime.

Precipitate—when we put a substance into any solution, and this causes the others to separate, and one of them to fall, we say it precipitates the falling body as when we pour *spirit of wine*, rectified spirit, into a brine or mixture of salt and water, the spirit unites with the water, which lets the salt fall or be precipitated to the bottom of the containing vessel.

Sands, are *siliceous*, or the well known flint stone in a pulverized state; or they are *calcareous*, being lime stone, or sea shells reduced to the state of sand.

Sulphate of lime, is plaster of paris; *see* gypsum.

Sulphuric acid, was formerly obtained by distilling green vitriol, a salt known in commerce as Copperas, and composed of iron and sulphuric acid, hence this acid was called *oil of vitriol*—but it is now procured by burning a mixture of sulphur and salt petre in chambers lined with lead, having their bottoms also covered with water to condense or absorb the acid vapors.

Vegetable acids—the *acetic acid*, is found in the sap of trees; the oxalic acid in sorrels; the tartaric acid in grapes, sumach, &c.; the citric acid in limes, whortleberry, cranberry, &c.—the malic acid in apples, and the gallic acid chiefly in the bark of most trees.

Vegetable Extract, was formerly used to designate all those substances, which may be extracted from plants by means of water, and which remained behind in the state of a dry mass, when the water was evaporated.

BROAD TAIL SHEEP.

MONTICELLO, June 12, 17.

Sir,—I have to acknowledge your two letters of April 8, and May 11, on the subject of the broad-tailed sheep. It is to be observed that there are different races of them, very distinct, and very different in merit. Three of these have fallen under my observation: 1st. Those from the Cape of Good Hope, with broad tails turned up like that of a nicked horse: long legs, light bodies, and slight fleeces. 2dly. Those from Algiers, of somewhat less stature, and better form and size: and 3dly. Those from Tunis, of low stature, round bodies, full fleeces, of good quality, hardy, thrifty, always fat, and of high flavored flesh.* It must have been of these last that Gen. Eaton brought to this country. I received myself a ram and ewe, brought in one of our vessels from Tunis direct: but the ewe would never breed; her massive tail never admitting the commerce of the ram. I have bred from the ram, in and in, for ten years past with a different race, and have found that when a ewe gets to be about ¾ pure blood, the same obstacle becomes so enlarged as to prevent further procreation. I continue this breed for the use of the table, and because the wool is as good as that of our ordinary sheep. I have merino's in a separate situation; but their wool cannot be used for coarse purposes, and there is no demand for it here, which renders them less profitable than others. I have in still a distinct and distant situation, another Spanish breed, which, yielding to the broad-tail as to the table, is in other respects the most valuable of all, hardy, heavy-bodied, heavy-fleeced, and of good staple, for country service. It is the best cross for the broad-tailed breed.—This information, slight as it is, is all I am enabled to give you, and pretends to no other merit than that of proving to you the sentiments of respect and esteem of which I beg leave to asure you.

TH. JEFFERSON.

GEO, W. JEFFREYS, N. C.

*We are happy to announce the arrival of a *pair of this race*, by the Plato, Capt. Packwood, as a present to the Editor's breeding stock establishmet from Com. Jones and Capt. Booth of the Navy. Of this, and of other very flattering evidences of the approbation of his undertaking, from officers of the Navy and others, the Editor will give a more particular account hereafter.—*Edit. Am Farmer.*

☞ AN INQUIRY.

The description of a system of Tanning, on a plan which could be executed by farmers in general, on their own plantations, would perhaps be of great service to many of your subscribers.

THE FARMER.

BALTIMORE, FRIDAY, DECEMBER 28, 1821.

PRICES CURRENT.

Flour $6, 4 months—Grain, of every kind, with the exception of Corn, which is a little in advance, same as last report—Shorts, 20 a 23—Bran, 18—Flax, seed, per bushel, $1—Hogs-lard, fresh, per lb. 10 a 12—Beef, Baltimore prime, $8 75 a $9 75—Cotton, N. Orleans, per lb. 18 a 20—Georgia, upland, do 16 a 18—Plaster Paris, per ton, $3 87½ a $4—Salt, St. Ubes, 55 cts. per bushel—Lisbon, do. 50 a 56—Cadiz, do. 50—Turks Island, do. 60 a 65—Butter, 25 a 31—Cheese, 8 a 12—Eggs, per dozen, 25—Potatoes, 40 a 45—Wood, hickory, per cord, $6 a $6 25—Oak, do $4 a $4 50—Pine, do. $2 75 a $3 25—Pork, hog round, $5 a $5 50.

Maryland Tobacco—Few sales, and same as last report.

Virginia & Kentucky Tobacco—none.

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